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THE

PLAGIARISMS

OF

JULIUS JEFFREYS, F.R.S.,

IN HIS TREATISE ON THE

STATICS OF THE HUMAN CHEST.

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"Recte faciens effugies calumniam omnem.
Nil pertinet ad te, quod is efficit suum esse."

J. C. SCALIGER.

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THE PLAGIARISMS

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Mankind instinctively cling to their possessions with a tenacious grasp, and especially on the occasion of others attempting to appropriate what is not their own. The feeling is a part of the law of self-preservation, and the right is universally acknowledged. Whether the endeavour be to secure landed or literary property, the justice of it is unquestionable, although it may not always be equally obvious in the two cases. The sensitiveness of authors sometimes leads them to exaggerate the value of their discoveries—to view with suspicion the labours of others in the same department of research, and not unfrequently to imagine a borrowing of their ideas, when the coincidence is the result of an independent train of thought; at the same time, there are cases where the similarity is so striking as to admit only one supposition as to its origin. If the sensitiveness is in the inverse ratio of the evidence which establishes the plagiarism, the reader will not charge me with an unreasonable share on the present occasion. The proof of the plagiarism does not rest on doubtful data, but on such as will be apparent to every understanding, and the degree to which it has been carried has no parallel in modern times.

Had it, in this instance, been employed in the elucidation of new truths, or with the pure wish to extend the boundaries of science, though this would have been no apology for the transgression, it would have modified my notice of it. It appears, however, in its least agreeable forms—in connexion with the spirit of making money, not by the exercise of professional talents, but by promoting the sale of an instrument, the utility of which should be its advertisement—and the benefit that of the public, unrestrained by patent rights.

The announcement of a work on the 'Statics of the Human Chest,' induced me to purchase it, anxious for additional information on the functions of the respiratory organs, and great indeed was my surprise, to discover, that the principles on which these Statics rest were entirely my own, and had been before the world, in several publications, from ten to fifteen years.* That he has altogether adopted my views, will be evident to the reader on a very slight consideration of the facts that will be brought under his notice. To any author this would have been naturally gratifying—if the source whence they had been derived had been indicated, but when they are put forth as original and of high practical value—demanding a modification of our opinions—the injustice calls for exposure. No claims are insisted upon in these pages beyond what the enlightened reader will award on the consideration of the evidence which will be adduced—and this will be fully and impartially stated. In the preface to his work, Mr. Julius Jeffreys remarks:

"The VIEWS which form the substance, as well as the title of the present work, will be perceived by the physiological reader to

* Experimental Inquiry into the Laws of Organic and Animal Life, 1829. Inquiry into the Principles of Medicine, Vol. i, 1834.

be, for the most part, *original;* and it is for him to judge of their correctness and importance. The subjects themselves are abundantly important.

"Part I. treats of the capacity of the chest, and the nature, condition, and duty of its gaseous contents, under the term *Statics*. *For these points an importance is claimed, hitherto exclusively attached to the act, and the air, of respiration; and a considerable modification, therefore, of our previous opinions is demanded.*"*

In the following extracts his views are stated at length.

"Commencing with the condition next to emptiness, namely, the bulk of air which we cannot expel, and which remains in the body after death, we may call this by a term which has been employed by others—the residual air. Then we have, on the top of this, the large bulk, which we can expel *after an ordinary outbreathing;* this may be named the *supplementary air*, it being the quantity filling the chest below the region of respiration. Upon this comes the ever-fluctuating air of respiration, which, in its influent state, may be known as 'the fresh breath,' and in its effluent state as 'the stale breath.' Over and above all this we have the capability of the chest to receive, when the fresh breath is already in, the occasional quantity which enters with a yawn or a sigh, and which may be termed the *complementary air.*

"When we shall duly consider the importance of each of these several bulks of air, *the fact must appear curious that it is the* BREATH *alone which is made the subject of speculation, and upon which the various theories of respiration up to the present hour are built.*"†

It is here distinctly stated, "that it is the *breath* alone which is made the subject of speculation, *and upon which the various theories of respiration up to the present hour are built.*"

He says "when the chest is distended with this complementary air, it will contain the four volumes as follow:

* Views upon the Statics of the Human Chest, Animal Heat, and Determinations of Blood to the Head. By Julius Jeffreys, F.R.S. Preface, p. ix. † Page 5.

	Cubic Inches.
Residual air	120
Supplementary ditto.....	130
The Breath	26
Complementary air	100
	376

" Of all these quantities, *the air of respiration, though much the smallest, has alone engrossed attention.*"*

" As already noticed, the air of respiration has absorbed the attention of chemical physiologists exclusively; all their inquiries have been directed to it. It is spoken of as acting upon the blood in the air cells, and, when breathed out, as having given up a portion of its oxygen to the blood, and having received from the blood carbonic acid and watery vapour.

" So familiar is the mind with this view as an established fact, that the announcement of the following as the correct view may appear an act of some temerity, but the truth of it may be readily and indisputably proved, while it points to others of much interest and importance.

" We may affirm, that the air of respiration does not, and cannot, ever enter the air cells, nor even the small air tubes. It has no *direct* concern in the oxydation of the blood, nor does it receive its carbonic acid and vapour directly from the blood. Furthermore, its constant presence in the air-cells would be injurious to health, and, probably, soon fatal to life. *The air of the breath has, in fact, no business with the blood, nor any footing in the cells of the lungs.*"†

" An indraught of breath of 26 cubic inches may mix itself, during the respiring act which brought it in, with 60 or at most 80 cubic inches of the resident air. Hence it follows, that when a corresponding quantity of air is *breathed out, it is not that which went in, but a mixture of that air with the uppermost resident air* "‡

Having dwelt at some length on the exposition of his views, and manifestly delighted with the idea of their originality, he breaks out:

* Statics of the Human Chest, &c. p. 12. † p. 13. ‡ p. 17.

"We now, surely, may perceive the beauty of the arrangement which lodges a large quantity of air durably resident in the cells; which is there during expiration as well as inspiration, and also at the interval between the two; *and is, therefore, carrying on its barter with the blood, at all times, continuously and uninterruptedly.*"*

The discoveries to which he lays claim as peculiarly his own—and which he regards as marking an important advance in our knowledge of the functions of respiration, may be examined under the following heads:

I. He contends that previous to his labours, the researches of physiologists had altogether been confined to the consideration of *the breath, or the quantity of air which is received into the chest by each act of inspiration:* That their attention had never been directed to the modifications of the large volume which is always contained within it. This is stated in several of the quoted passages; and he endeavours, on numerous occasions, to show the immense light which a knowledge of these modifications throws upon the functions of respiration.

II. The next grand and original truth at which he arrives, is, that the breath, or the air of respiration, neither enters the air-cells nor the smaller air tubes, that it has, in fact, "no *direct* concern in the oxydation of the blood, nor does it receive its carbonic acid and vapour directly from the blood." The stratum of air which is the lowest in the series, is of course viewed as alone engaged in this important process.

III. The discovery which he now lights upon is, that the air which is emitted by the act of expiration, is not that which immediately "*went in, but a mixture of that air with the uppermost resident air.*" "It is this resident air which performs all the duty of oxydating the blood,

* Statics of the Human Chest, &c. p. 22.

and which receives from the blood its eliminated carbonic acid, and watery vapour. The air of respiration performs no direct duty in connection with the blood. In its fresh state it does not come even near to the cells."

IV. The next important discovery which his splendid researches enable him to make, in elucidating the functions of respiration is, that "according to the usual view, it was necessary to suppose that the action on the blood *must be constantly fluctuating, being at a minimum at the end of an expiration, and increasing to a maximum during inspiration.* Such according to the common view must have been the case."

His vastly interesting and original principles show how admirable and beautiful are the arrangements of nature, when studied with the penetrating sagacity of a philosopher —a philosopher who looks directly at the operations of life—from a point of observation which is quite his own. It is delightful to dwell on the comprehensive character of these principles—the wide range of thought impressed upon them—the subtlety of mind which they have exercised—the elaborate care and consideration manifested in their development, and the exquisite judgment to be traced in their application, exposing the errors of previous physiological inquirers, as well as pointing out the narrow limits circumscribing their views. These principles enable us to appreciate "the beauty of the arrangement which lodges a large quantity of air durably resident in the cells; which is there during expiration as well as inspiration, and, also, in the interval between the two," so that there is always an uninterrupted free trade carried on between the blood and the air. On the old views, he shows this to have been impossible. They, indeed, were the sliding scale, at one time admitting a great deal of air, at

another, scarcely any at all. His views are the fixed duty, which maintain a uniform relation between consumption and supply. Whether the necessities of the blood be great or small, the beauty of the arrangement furnishes the precise quantity required. He concludes his profound and original investigations on this subject, by remarking, "we now see the necessity of the *resident* air being large in quantity, and the fluctuating air—the breath, much less."

In my work entitled, "AN EXPERIMENTAL INQUIRY INTO THE LAWS OF ORGANIC AND ANIMAL LIFE," the leading principles by which it is distinguished, are employed in tracing the important modifications which occur in different states of the animal system, in health and disease, *not only in the amount of blood in the lungs, but in the volume of air acting on this blood.* So far from my attention having been absorbed with the consideration of "the air of the breath," as it is oddly designated, or with the quantity received by a single inspiration, the changes of the volume of the *whole* air within the lungs, and the effects which flow out of these changes, are analyzed and illustrated at considerable length in several of my publications. The evidence of it will be adduced in the examination of his important discoveries.

Discovery I, is, that the breath has hitherto been alone the subject of speculation. The following extracts from the "Experimental Inquiry," expose the injustice of this assertion.

"From the little already stated concerning the action of inspiration and expiration, it is manifest that the *proportion* of blood and *air* is subject to great variations; and it is my intention to explain more particularly the nature and origin of these.

"XVII. It is not easy to ascertain the quantity of air which is evolved at each ordinary expiration; this is so materially modified by the state of the mind, system, and capacity of the chest, that great

discrepancies unavoidably exist in the results of the most distinguished chemists. But the data which I shall presume to establish, and the reasoning which will naturally flow from them, will be little affected by the varieties of opinion.

" Dr. Bostock has paid considerable attention to the subject of respiration, and his contributions are neither few nor unimportant; and, on this account, I shall draw my deductions from the experiments of this talented individual.

" XVIII. By *an ordinary* expiration, 40 cubic inches of air are emitted; but after this we are enabled to expel a considerable portion, and this quantity is estimated at 160 or 170 cubic inches, ' so as to give 200 or 210 cubic inches as the difference between the states of ordinary inspiration and of forced or extraordinary expiration.'* As it is impossible to empty the lungs completely, many calculations have been made concerning the quantity of the *residual* air which must necessarily remain after violent or long continued expirations; and this most probably amounts to 120 cubic inches.† From the above statement, it is clear that, after an ordinary expiration, 280 or 290 cubic inches remain in the lungs, in other words, 7 or $7\frac{1}{4}$ of ordinary inspirations. What is the intention of Nature in giving to the lungs a capacity sufficient to contain almost 300 cubic inches of air after the evolution of that portion which is no longer fit for the animal economy? The explanation of this intention will throw new light on many mysterious changes of the system." ‡

Here, at the very commencement of my inquiry, the object is less to determine the amount or office of ' the air of the breath,' than the volume of the air always existing in the lungs, and the important functions performed by it in the process of respiration. The data on which his views and reasoning rest, and the general conclusions flowing from them, are essentially the same. He estimates the *residual* air at 120 cubic inches, the quantity given in the preceeding extract. The *residual* and the *supplementary* volumes of air which ' are permanently

* Bostock's Elementary System of Physiology, Vol. ii. p. 25.

† Ibid. p. 29. ‡ Experimental Inquiry, p. 12.

resident in the chest,' after an ordinary expiration, is stated as above 250 cubic inches; by me, at 280 or 290 cubic inches.

Discovery II. is, that "*the air of respiration neither enters the air-cells nor the smaller air-tubes;*" it has in fact "*no business with the blood, nor any footing in the cells of the lungs;*" nor has it any "*direct concern in the oxydation of the blood.*" The same views are distinctly stated by me:

"The air which is received by any single inspiration, does not immediately act upon the blood; its office is to supply the deficiency occasioned by the previous expiration; and after several *series* of such expirations it is then brought into *intimate* contact with this fluid, and tends to continue the successive alterations which it undergoes."*

It is scarcely possible for words to explain more clearly the functions assigned to the breath or air of respiration, and yet he adduces the same doctrine as original, and regards it as demanding 'a considerable modification of our previous opinions.'

Discovery III. is, that the air breathed out, is not that "*which went in, but a mixture of that air with the upper resident air.*"

In the Introduction to my work occur these remarks:

"By taking into consideration, *that a small quantity only of the air within the lungs is at any one moment deteriorated*, and, still further, *that the left ventricle contracts* 70 *or* 80 *times per minute*, in order to propel the arterial blood which is transmitted by the lungs, we shall have reasons sufficiently ample to account for the possibility of these organs bearing such changes, and for the ease with which the system is supported in an equable temperature."†

It is further stated:

"I have observed in Chap. I., xix. and xx. that the air inspired is not *immediately* expelled by expiration, but that a portion is emitted—

* Experimental Inquiry, &c., p. 13. The words and passages in italics, as originally printed. † Page xx.

probably the whole which is deteriorated,—while a much greater quantity of air at all times exists in the lungs; and from this it is to be inferred, that the successive chemical changes are slow, and of a delicate description."*

It is not necessary to multiply passages expressing the same fact, the following, however, will be excused:

"It is impossible to suppose that air is deteriorated immediately on its being inspired; if this were allowed, the whole quantity which belongs to the lungs would be unfit for its vital function, as this must be contained in the air-cells and subject to the influence of the capillary vessels, and therefore placed under circumstances that would deprive it of its properties."†

Discovery IV. is, that according to all previous views "it was necessary to suppose, *that the action on the blood must be constantly fluctuating*, being at a minimum at the end of an expiration, and increasing to a maximum during inspiration."

The leading argument throughout my work is to prove, that as it is not in our power to *diminish* the residual air in the chest, acting on the blood, the chemical changes in the latter will be proportionate to the quantity of blood exposed to it. Whether this principle be correct or otherwise, is not the question, nor is it on this occasion necessary to examine it.

My views on the important subject of animal heat are based altogether on the established fact, *that the volume of air in* IMMEDIATE *contact with the blood is not susceptible of any important modifications.* This opinion is stated in the subjoined extracts:

"As the blood is not immediately acted upon by the fresh air which is received, it follows that the alterations are to be referred *to that already existing in the pulmonary cells;* and, moreover, it is natural to suppose, if we diminish the quantity of blood, that the

* Experimental Inquiry, &c. p. 63. † Page 14.

chemical changes will be more complete, because the air will have a less portion to oxygenate.* ||

"This contrivance (the structure which allows a large quantity of air to exist in the lungs,) is a wise provision of Nature, as it enables an individual to speak, laugh, run, in fine, to accommodate himself to any kind of exercise where expiratory actions are required, without immediately affecting the office of the lungs, which would necessarily be implicated if the inspired air were instantaneously appropriated to those changes which are indispensible for the continuance of life."† §

XVIII. "The lungs, as stated, always contain a *considerable quantity of air;* and as this is that portion which *immediately* acts upon the blood, if we diminish this blood by a series of expiratory actions, it is philosophical to suppose that it will be more perfectly oxygenated, because a smaller quantity is submitted to the influence of that important agent."‡

Numerous other passages might be given in confirmation of these views shewing a perfect coincidence with the doctrines advocated by Mr. Julius Jeffreys, but it is not necessary. As already remarked, the reasoning in almost every page of the "Experimental Inquiry" rests on the clearly expressed opinion, that the *volume* of air acting on the blood cannot be diminished, consequently cannot be affected by expiration or inspiration. There is not, indeed, an important principle bearing on 'the statics of the human chest,' nor an application of it, that is not found in my works.

He presents a diagram to explain how the upper stratum of air gradually descends to get into the air-cells. "It may be asked," he says, "how then are the purposes of respiration fulfilled, and how are the smaller air-tubes and cells supplied with air sufficiently oxygenous? Two ways offer themselves. The first and chief is, *that of a progressive intermixture, proceeding by steps from without*

* Experimental Inquiry, &c. p 15. † Page 14. ‡ Page 16.
|| § The passages in italics, as originally printed.

inwards at each inspiration." In treating of the same subject it is stated by me, "that the air which is received by any single inspiration, does not immediately act upon the blood; its office is to supply the deficiency occasioned by the previous expiration; and after several *series* of such expirations it is then brought into *intimate* contact with this fluid, and tends to continue the successive alterations which it undergoes." Here is precisely the same view. In this case he is so far original, as to convert the *series* into *steps*.

By the aid of his original views he proceeds to shew how the breathing is affected by violent exercise, as running for example. He remarks:

"An unpractised runner, for instance, tries to relieve himself by the former method; but he soon feels the consequence of letting out too much of his resident air, and drawing in too deeply atmospheric air, fully oxygenous, and perhaps also cold. He gets out of breath—that is, when he wants more air than usual, he cannot take in so much; a kind of asthmatic spasm prevents him from getting air enough down, although the chest is not really more than half full. On the other hand, by practice he instinctively learns to keep adding air to that already present, and to breathe nearer to the top of his chest. He can then respire deeply without drawing in the fresh air suddenly and too far into the lungs. Also, by increasing the quantity of resident air, his cells are more fully expanded, there is more surface of action, and the blood vessels are rendered less tortuous still, by which they admit, with less distress, of the quickened circulation through them."*

It is stated by me:—

"The short breathing which an individual exhibits after violent exercise, as after running, is not occasioned by any condition of the heart or circulation, as is generally supposed, but arises from the diminution of the ordinary and stationary quantity of air belonging to the chest, and it ceases as soon as the repeated inspirations have re-established the order of nature."†

* Opus cit. p. 32. † Experimental Inquiry, p. 14.

The following extract, bearing on this subject, is from a paper of mine which was published in 1840 :—

"Violent exercise, as running for example, changes the natural character of respiration. During the almost suspended breathing at the beginning of the exercise, the flow of blood through the lungs is very much impeded. On its cessation, the inspirations are greatly accelerated, in order to facilitate the transmission of the several quantities of blood previously sent out by the right ventricle. The balance of circulation would be restored were the exercise long persevered in, as is strikingly exemplified in persons practised in running. At first they are distressed, breathing with difficulty, but so far from this increasing, the respiration after a time gradually becomes less laborious, they having arrived at what is commonly called the second breath. The hurried respiration arises principally from the cause assigned—more blood being conveyed by the right, than is removed by the left ventricle."*

Having exposed, with as much brevity as the inquiry will allow, the happy coincidences of this writer with the leading views contained in my work, we will proceed further in the interesting search after others, which pervade almost every page of his treatise. In the EXPERIMENTAL INQUIRY, the modifications in the generation of animal heat, in various natural as well as induced circumstances, are considered at great length. He has passed over in silence one condition which is studied in connexion with it, viz., *the changes in the* QUANTITY *of blood in the lungs in different states of the animal economy*: The *changes* in the QUALITY of it are brought, however, under consideration, and are explained almost in my own precise terms; and every other view of any importance is adopted, and the whole is advanced as original and of great practical value.

The preceding extracts do not exhibit that kind of coincidence which occasionally occurs in scientific researches—

* The influence of respiration on the motion of the blood. The Edinburgh Medical and Surgical Journal, No. cxliv, page 140.

and which is gratifying to labourers engaged in the same field. Minds at different degrees of elevation—looking upon the phenomena of nature in new aspects, at times hit upon correspondent ideas—general conclusions having strong features of resemblance, but when the entire and practical views of a previous writer, essentially the same in form and application, are brought forward by another, the term coincidence is much too limited in its acceptation to express such agreement. That which most fitly designates it may be left to the suggestions of others. In the further exposition of the principles of this writer, attention will be confined to a few only of the more important.

Concerning the mode in which the System adapts itself to high Temperatures, he observes, in alluding to the experiments of Crawford, Jurine, Lavoisier, and Dr. Edwards, that they point "to the reasonable conclusion, that the quantity of animal heat generated bears some inverse proportion to the temperature of the air. It has been rightly observed by this able physiologist, and by others also, *that the lesser density of warm air would cause a given quantity entering the chest to convey in less oxygen than in the case of cold air.* As, however, in a high temperature we need less heat, we may certainly conclude *that our respirations do not increase in volume, and therefore that the diminished density of the air may so far* favour a diminished production of heat."*

The three former authorities contend that there is a less consumption of oxygen when the system is exposed to high temperatures; they do not, however, as far as my study of their works enables me to form an opinion, attach any great importance to the lesser density of the air, but refer the effect especially to modifications in the properties of the venous

* Opus cit. 64.

blood brought to the lungs. The doctrine of Edwards is, that animals subjected to a high temperature have a less power of producing heat, but he does not attempt to explain the nature of this power, nor does he appear to trace it in any degree to the lesser density of the air.* I have recently examined his invaluable treatise with great care, in order to ascertain his precise views on this subject, and can discover one passage only bearing directly upon it. Nor is the diminished rarefaction of the air, as a cause limiting the production of animal heat, dwelt upon, either by Bostock or Adelon, in analyzing the labours of Crawford, Jurine, Lavoisier, and Edwards. The latter remarks: "Par example, l'air étant plus rare en été, et en même temps plus chaud, mais à un degré qui ne change pas les mouvemens du thorax et du cœur, quel sera l'effet de cette élévation de temperature? La raréfaction, lorsqu'elle est assez considérable, diminue la consommation de l'air: la chaleur agira-t elle dans le même sens ou en sens inverse, ou sera-t-elle sans affluence sur le phenomème? Je ne connais pas d'experiences où l'on ait apprécié la part respective de ces deux agens; mais il en est qui donnent le resultat de leurs actions réunies."† Bell, of Manchester, who studied the effects of high temperatures, alludes to the rarefaction of the air, as one of three causes, enabling the system to bear an exposure to great heat, but in his inquiry the rarefaction contributed to the effect, by diminishing the particles brought into contact with the surface of the body.‡

* For information on this subject consult the admirable article on animal temperature, in Bostock's physiology, 3rd edition.

† De l' influence des agens physiques sur la vie. Par W. F. Edwards, p. 197.

‡ Elementary System of Physiology. By John Bostock, p. 463, 3rd edition.

The reference to this subject is made, not to enforce on my part any decided claim to originality, though the view is urged by me as one of considerable value, in analyzing the influence of high temperatures on the animal economy, but to shew how closely Mr Julius Jeffreys has walked in my footsteps. He has adopted, without the slightest acknowledgment, the fundamental principles of my work, treating of the statics of the chest, as well as the applications of them elucidating many interesting vital conditions. How far this charge is well founded others must decide.

The varying *density* of the air in winter and summer is employed by him in different portions of his treatise, to explain certain phenomena. He remarks:

"There can be no question, then, that the explanation afforded by some of the larger supply of oxygen when the temperature is low, namely, that then the air is more dense, is altogether inadequate to account for the supply needed. It is a happy coincidence as far as it goes, which only holds good indeed under the same barometric pressure; we must then look for an explanation of the increased supply of oxygen elsewhere, and we shall find the main source of an extra supply in the fact, which from its importance cannot be too strongly impressed on our minds, that the volume of the air of respiration is ever variable; the breathing being increased when more oxygen is wanted, and decreased when less."*

Chapter viii. of the EXPERIMENTAL INQUIRY is entitled, "*the means by which the system is enabled to bear a temperature much superior to that of the body.*" In the consideration of the subject the following passages occur:—

"CXCVI. After an ordinary expiration, the quantity of air remaining in the lungs is estimated at 280 to 290 cubic inches; but if the temperature of the body be increased from 5° to 10°, the air will be much rarified, and, consequently, the same quantity will not continue to act upon the blood. It will undergo this change before it is inspired, which will lessen the quantity received, and the internal warmth of the chest will also tend to carry this change

* Opus cit, p. 68.

still farther. So we observe that two causes are in operation, both of which will diminish the usual proportion of air acting on the blood; *and, moreover, this diminution will be in the direct ratio to the increase of temperature, retarding its influence, not by the generation of cold, but by setting limits to the generation of heat.*"*

"CCIX. There is a great difference between the powers that *relieve* the system from the effects of heat and those that *circumscribe* its evolution. The former are simply the extension of the ordinary and obvious laws of the animal economy; the latter are the result of a principle less evident, and exercised only on extraordinary occasions. The excessive heat of 240° or 260° would destroy the body, if the 260° increased the generation of heat in the ratio of its numerical progression; but every degree, from the temperation of the body to 260°, *modifies the production of heat by augmenting the rarefaction of the air within the chest,—thus successively diminishing the quantity of oxygen submitted to the influence of the blood.*"†

"If, therefore, the air is rarified before it is inspired, and if its general bulk be subsequently materially lessened; and if in conjunction with these two conditions, we consider, *that the quantity of air in the lungs indispensable* to maintain the powers of life is very much rarified by an extensive and constant generation of caloric, we are enabled to appreciate the boundaries which Nature has set to the generation of animal heat."‡

Discovery V, The Connexion between Dietetic Substances and the production of Animal Heat.—This interesting and important department of scientific research has of late years been ably cultivated by Liebig, and many practical results have been brought out. Mr. Julius Jeffreys states, that he had also arrived at the same and other closely related discoveries, and had committed them to writing, but the publication had unfortunately been deferred from time to time.‖ He remarks on this subject:

"In endeavouring to ascertain the natural provision for reducing so greatly the production of heat, I was led to contrast with this state of things that of the condition of human beings in the polar

* Experimental Inquiry, p. 176. † Page 187. ‡ Page 188. The passages in italics, as originally printed. ‖ Vide Opus cit. p. 197.

region; and was led, as already remarked, to see in the difference of diet a considerable latitude in the ultimate sources of heat. This contrast in the usual quality and quantity of the food of the arctic and tropical races offers so inviting an explanation, as to tempt the mind into resting satisfied with it as sufficient to explain every case; but we must not allow our imagination to be thus carried away. Fully appreciating the fact that a material difference in the diet does exist, and must tend to the development of very different degrees of heat, we shall find that it will not account for many cases, especially such as I have described."*

"That since by far the greater part of the food is thrown off from the lungs, we must look closely to the quantity of diet as the source *in general* of the different quantities of heat required in different countries; and that we find, in the case of the inhabitants of intensely cold regions, both the quantity and quality of the diet to bear a close relation to the very large quantity of heat required to maintain the animal temperature in those regions; while, on the other hand, the fruits and acidulous diets, for which there is an inclination in the tropics, may with good reason be considered to yield less heat in passing into carbonic acid and water, since a large portion of the oxygen requisite is already solidified in such vegetable principles, and, being in union, is less likely to generate heat."†

In conclusion he states, "thus guarded *our* theory of animal heat will be found to answer to every circumstance of animal life."‡ What would his theory be if every one claimed his share of the facts on which it is built?

Chapter vi. of the EXPERIMENTAL INQUIRY, is entitled *the manner in which the system is adapted to the influence of cold*, and in this occurs the following passage:—

"Nature has not only been provident in harmonizing the mind of man to his situation, but has also been careful to provide him with an abundance of whatever is required to protect the body from the inclemency of the cold, and to support the vigour of the constitution from its influence. The food of Northern inhabitants is substantial and nutritious; *it is generally of an animal nature;* the

* Opus cit. p. 76. † Page 83. ‡ Page 85.

clothes in which they are dressed are the skins of different kinds of animals, or, if the labour of art be employed. they are such as are well adapted to defend the surface of the body."*

From a more recent work† the following extracts are taken :—

"The inhabitants of northern climates possess greater vigour of constitution and physical power, than those of warm and genial latitudes: and it could not possibly be otherwise. *The liberal use of animal food, as well as of the most nourishing and stimulating vegetable productions*, exerts a powerfully invigorating influence on the vital energies, much increased by strong muscular exertion, which the natives of southern regions could not make, even if they had the disposition, in consequence of the oppressive heat of the sun."‡

"In warm and genial climes, where vegetable nature displays whatever is calculated to delight or gratify the senses, her productions, profuse and almost spontaneous, are peculiarly adapted to the constitution of the inhabitants of such climes, who, requiring neither strong stimulating drink, nor highly invigorating animal food, are best supported by such mild nourishment as gently exhilarates, or refreshes the system,—*nourishment, which is abundantly provided for them in a vast variety of rich and cooling fruits.*"||

"The qualities of the blood are more or less rich and invigorating according to the purity of the air inhaled, *and the nourishment afforded by the food digested.* A deficiency in the qualities of either immediately produces corresponding effects on the whole system. If the blood possesses its natural properties, the numerous powers of life are maintained in healthy action; if it be deficient in them, these powers languish and exhibit manifest symptoms of derangement."§

The connexion between food and the properties of the blood, or the generation of animal heat, is clearly stated in

* Experimental Inquiry, &c., p. 150.

† An Inquiry into the Principle and Practice of Medicine. Vol. i. 1834. ‡ P. 196. || P. 194. § P. 208.

in the above passages, and others in illustration of the same fact might be selected if necessary. The views which they contain were published many years anterior to the valuable labours of Liebig.

Discovery VI. *The respiration is increased according to the demands of the system for oxygen.*

He observes:

"We may now perceive another reason, in addition to those noticed in the first part of this work, for that peculiar structure of the chest which places the air of respiration intermediately between the supplementary and complementary space; so that after a full ordinary inspiration, if need require it, an additional quantity of air may be drawn in, corresponding with a portion of the complementary space. And again, if needful, the expirations may be increased, breathing out being carried to a greater extent. In this case the respiration will intrude upon the usual supplementary space. In this manner by habit an increased respiration may be, and there can be no doubt oftentimes is, permanently established."*

In a passage already quoted he says: "that the volume of the air of respiration is ever variable; the breath being increased when more oxygen is wanted, and decreased when less."*

He observes: "and again, if needful *the expirations may be increased,* BREATHING OUT BEING CARRIED TO A GREATER EXTENT." He here speaks of the *expirations* being increased. In the "Experimental Inquiry," the two acts of respiration, inspiration and expiration, are studied separately in their relation to the production of animal heat, which had not been done by any previous inquirer, and it is shewn that a preponderance of expirations is attended with an increased production of heat.

"XIV. An expiration is an act by which deteriorated air is expelled: but this is only one part of its important function. It is the effect of inspiration to facilitate the motion of blood through

* Opus cit. p. 69.

the lungs; but it is that of expiration to retard it. If, then, we have a preponderance of expiratory actions we diminish the quantity of blood generally circulating through the respiratory organs; and this being the case, we shall observe the heart beating with unusual vigour, at times amounting to palpitation, the pulse quick and strong, the countenance flushed, the whole surface of the body exhibiting improved circulation, and increase of temperature."*

"An inspiration draws in the quantity of air necessary to support the chemical changes of the blood; an expiration expels that which is deprived of its vital properties. *It may, perhaps, therefore, be inferred, that one act will invariably succeed another, and that the quantity of air inspired will be exactly proportionate to that emitted by the previous expiration, so that the generation of animal heat cannot be influenced by a preponderating degree of completeness or frequency in either of the individual acts.* Such inferences will, however, be found, on mature examination, to be incorrect. Inspiration and expiration are susceptible of two modifications, *a change in the frequency and in the fulness of their respective acts.* In speaking, for example, there are many expirations in quick succession, whose constant expenditure of air is supplied by deep inspirations, made at intervals, which are equivalent to the more numerous but less complete expirations. It may, perhaps, be thought that the qualities of the blood cannot be much influenced by a preponderance in the frequency of expirations, as the inspirations, though few, contribute, within a given period, a quantity of air equal to that which has been expelled. But that the properties of the blood are thus considerably affected, and that this is a necessary consequence of frequent expiration will be evident on considering the condition of the vital fluid in the two opposite states of respiration."† ‡

He has generally been exceedingly guarded in not employing the precise terms used in my writings. In the following passage, nevertheless, his argument, in language only slightly altered from my own, in relation to the frequent changes in the volume of the air in the chest, *and*

* Experimental Inquiry, p. 10. † Principles of Medicine, p. 307.

‡ The passages in italics, as originally printed.

the consequent modification in the production of animal heat, is one of the distinguishing peculiarities of the principles developed at great length in several of my productions. It is, in fact, one of the peculiarities which was more or less objected to by the reviewers, the truth of which, however, has appeared to be strengthened by much subsequent consideration.

The following extract from his work, illustrates very happily the tact with which he can borrow. He is attempting to shew that the oxydation of the blood is according to the frequency and completeness of respiration, and as materially influenced by the *character* of the two acts of it, which is one of the chief and peculiar doctrines advocated by me in the examination of the important subject of animal heat.

"In short, the *ventilation* of the cells depends not only on the volume of the breath drawn in upon the resident air, but much also on the quickness of the inspiration. We might conceive it possible to draw the air of respiration into the chest so gently as not to disturb the resident air at all,—as not to mix even with any portion of it. If it were then breathed out with equal gentleness, it would return, having performed no duty in ventilating the chest; it would, in fact, come back as it went in, having left none of itself behind, nor received in exchange any of the resident air fraught with carbonic acid. Now, although so extreme a case as this may not be attainable in practice, owing to the mobile and miscible character of air, it serves to illustrate the fact of the degree of the commixture, and consequent ventilation of the cells, *very much depending on the force as well as volume of the inspiration.*"*

In place of stating that the *oxydation* of the blood is according to the frequency of respiration, he says, "*the ventilation of the cells* depends not only on the volume of the breath drawn in upon the resident air, but much also on *the quickness of the inspiration.*" The free *ventilation* of the cells is necessary to the perfect oxydation of the

* Page 72.

blood. He cannot have an increased "quickness of the inspirations" without a corresponding increased quickness of the expirations. The air can be inhaled in quick successive acts only in consequence of being sent out by previous quick expiratory acts. Such a condition is the frequent removal of the air, the better oxydation of the blood and the consequent increased generation of animal heat. He admits these effects, and reasons upon them, but he avoids the use of plain terms, which would indicate the source of his ideas. The following passages from my works, lay down the principles supposed to regulate the production of animal heat, and show in what way this is modified by respiration—a discovery to which he lays claim, and to which he attaches great importance.

"1. Animal heat is proportionate to the capacity and activity of the lungs, not understanding by *activity* the number of respirations, but the number and character of its compounded acts, inspiration and expiration.

"2. This principle (animal heat) is proportionate to the chemical changes in the lungs, and the perfection of all other functions is also in the direct ratio to these."*

"XLII. If we diminish the respiratory action, we lessen the generation of animal heat."†

"The function of respiration, as it affects directly the qualities of the blood, and indirectly, by means of this fluid, every part of the organized system, merits the first consideration. The character and extent of the chemical changes to which it gives rise, can be ascertained only by a knowledge of its two acts, inspiration and expiration.

"To the neglect of physiologists in not investigating the influence of these two functions separately, is to be attributed much of the absurdity and incompleteness of the views generally held concerning the production of animal heat, and the manner in which the circulatory system is liable to be disturbed, as well as the origin

* Experimental Inquiry, p. 34. † Ibid. p. 35.

and nature of numerous diseases. It will scarcely be doubted, that it is by means of respiration that the blood is oxygenated, and that whenever its properties are vitiated in consequence of the oxygenation not being complete, the whole system will be more or less deranged."*

" If the respiration be accelerated, and the contractions of the heart increased to a hundred, all other conditions being equal, the mass will circulate through the lungs in one-fourth of the time, and the production of animal heat will be augmented in the same proportion."†

Discovery VII.—*Concerning the invigorating and depressing effects of exercise*—He remarks :

" Again, in the case of a person in health commencing a course of severe exercise, we cannot doubt that the loss of flesh is closely connected with the increase of the circulation of the blood, and the consequent increase in the volume of the respired air, and also with the increased production of heat, which corresponds with the other phenomena.

" Lastly, we know that the absorbed matter of the body must, in part at least, pass off in respiration, and by the skin; and must therefore, to that extent, supply elements available for the production of heat."‡

" In proportion as the action of all the voluntary muscles accelerates the circulation, it multiplies the number of particles travelling the capillaries in a given time. Thus much more action between particles must take place, *and the supply of them is kept up at the same time by the return into the blood of an increased quantity of matter ;* for the increased flow of blood stimulates the nerves and minute vessels, and amongst them the absorbents, to greater activity. This familiar view affords us a ready and sufficient explanation of the production of heat, and the loss of flesh attending labour, so long as the exertion has the effect of materially accelerating the circulation. As soon, however, as the heart ceases to be excited, and the smaller vessels also bear the pressure of the fluid without increasing their action, the quantity of action throughout all parts of the system diminishes : there is then less laboured respiration, less development of heat, and a less change of the fabric of the body. Thus

* Principles of Medicine, p. 306. † Ibid. p. 319. ‡ Opus cit. p. 87.

we perceive that labour *may* or may *not* be attended with a corresponding production of heat, consumption of oxygen, and waste of the fabrics, according as the person is or is not accustomed to it."*

"This view," he observes, "is reasonable and intelligible, and far more in accordance with the observed proceedings of nature, than the notion that there is only vital power enough in the system to protect the muscles from the ferocity of oxygen which had been (unaccountably) allowed to enter the system, and take up its position everywhere."† There is not in these extracts an idea but what is clearly expressed in the following passages. Indeed the perfect coincidence is remarkable. The views are employed by him to expose the fallacies pervading the doctrines of Liebig.

"Exercise, by agitating the body, directly influences the functions of the abdominal organs, in consequence of which their several secretions are poured out more abundantly, and with greater regularity, than usual—an effect which may be considered, in some degree, though not entirely, independent of the chemical changes induced in the blood; for, as soon as the circulating fluid has acquired additional stimulating qualities, and is propelled by the heart with increased vigour, the chylopoietic viscera generally are excited to greater action, and this effect continues long after the cessation of the cause which, in the first place, produced it. The blood is not only improved in its chemical properties by passing through the lungs more frequently than usual, but it also *acquires additional nourishing qualities from the more abundant and healthy contributions furnished by the digestive apparatus.* That the chemical changes in the lungs are increased by exercise, of every kind, is a fact admitting of direct proof."‡

"Moderate exercise is productive of additional vital properties, but, when excessive, it lessens those properties. An excited condition of the system not only tends to invigorate the powers of life, as explained in the preceding pages, *but also to exhaust them, by accelerating the expenditure of the nourishing properties of the blood,*

* Opus cit. p. 216. † Page 217. ‡ Principles of Medicine, p. 350.

*an effect necessarily produced by augmenting the different excretions of the body, so that if exercise is severe, this expenditure being proportionably great, the circulating fluid is at last deprived of those properties which enable it to perform its numerous and important offices.** The chemical changes in the lungs may be considered as rendering the blood nutritious, by imparting to it oxygen, and extracting from it carbon, but, *if it has become exceedingly impoverished, from abundant excretions, the inspired air will not modify it to the usual extent, or in other words, will be incapable of supplying the vital properties which have been gradually dissipated by the inordinate activity of the excretory functions.* It is, moreover, probable that, under these circumstances, the distribution, as well as the qualities of the blood, is very much disordered, so that this fluid may be unfavourably situated in the lungs for proper chemical action, which will, also, in part explain the cause of its deterioration."†

"It is easy to adduce positive evidence to show, that the generation of animal heat is proportionate to the equable distribution of the blood and its accelerated circulation. Muscular exercise affords a striking illustration of the fact. If it is severe, or long continued, profuse perspiration breaks out—an unequivocal indication, that an additional quantity of heat is produced, which cannot justly be ascribed to any other causes than those which have been assigned."‡

There is not indeed an interesting fact or series of vital actions, which these views elucidate or illustrate, but what he has lugged into his treatise as evidence of the beauty and originality of his principles.

Discovery VIII. *The heat produced is for the most part proportional to the freedom of the respiration.* In touching upon this subject he has brought forward the most striking *peculiarity* of my principles in connection with the study of the evolution of animal heat—a peculiarity which met with decided objections from the reviewers,

* This passage in italics, as originally printed.

† Principles of Medicine. p. 352. ‡ Ibid. p. 320.

who imagined that it was not in accordance with the chemical theory which is uniformly maintained by me. He remarks :

"We are wont to consider respiration a heating process, and in this we are doubtless correct; we are right, also, *in the opinion that the heat produced is, for the most part, proportional to the freedom of the respiration*,—that is, that the oxygen introduced in respiration must increase with the increase of the elements which have to be discharged from the lungs; *but we greatly err if we think, because more air must be had to produce more heat, that therefore more air respired must always produce more heat* The system must have more air when it requires more to increase the heat-developing combinations, since it cannot increase these without more oxygen; *but it by no means follows that the presence of more oxygen will force it to increase the combinations;* and, if we are duly observant, we shall find abundant proof that the quantity of the already respired oxygen which is *employed, is altogether determined by the wants of the system, and is under the control of the vital powers.*

"Hence, if we would increase the frequency and depth of our respirations, *at a time when no increase is called for to carry off more matters from the system, either derived from the fabrics of the body or from the food, there will not be any consequent increase of heat. No more heat will be developed, nor any more oxygen employed, so far as our observations permit us to decide, than previously; but, on the contrary, an opposite effect will be produced.* The additional air introduced into the chest will have a cooling effect."*

He says, "we greatly err if we think, because more air must be had to produce more heat, *that therefore more air respired must always produce more heat.*" In numerous passages in my writings, as well as in the extracts already given, it is shewn, that the *quantity* of air inhaled *is only one condition connected with the increased or diminished production of animal heat.* The quantity as well as the *quality* of the blood existing in the lungs, is the other important condition, and without this being kept

* Opus cit. p. 148.

in view, the study of the mere volume of air inhaled or expelled, will afford no satisfactory explanation of the laws regulating the evolution of heat, which is precisely his view. Many illustrations of a *reduction* in the temperature of the body, from a disturbance in the natural relations between the inspired air and the quantity as well as the *quality* of the blood brought to the lungs are given in my writings. The following passages bear directly on this subject:

"The modifications in the properties and distribution of the blood cannot, however, be justly ascribed to the derangement of the respiratory function solely, when that derangement is of long continuance, since, in that case, they are partly produced by disease of the different organs which contribute, either directly or indirectly, *to the production of chyle: for if this fluid is deficient in its ordinary nourishing qualities, the arterial blood will necessarily experience a deterioration*, although the conditions of the respiratory organs, essential to the chemical changes of the blood, may at the same time be only slightly affected."*

"The chemical changes in the lungs may be considered as rendering the blood nutritious, by imparting to it oxygen, and extracting from it carbon, but if it has become exceedingly impoverished, from abundant excretions, the inspired air will not modify it to the usual extent, or in other words, *will be incapable of supplying the vital properties which have been gradually dissipated by the inordinate activity of the excretory functions.*"†

"If the vascularity of the lungs be diminished in advanced life, from the obliteration of a portion of their vessels, it is quite clear, that they are not then so well calculated to expose the sanguineous fluid to the influence of the *inspired air*, as in infancy and childhood, when these vessels are much more numerous and healthily consti-

* Principles of Medicine, p. 302. † Page 352. The passage in italics, as originally printed.

tuted; hence the blood in old age, partly in consequence of this circumstance, will, in the greater number of instances, be destitute of highly nourishing and stimulating properties."*

Without adducing additional evidence of the fact, is it not obvious, that the extracts from 'the Statics of the Chest,' in language only slightly modified, contain precisely the same views. There is not, indeed, an important idea enforced by him, but what is clearly embodied in the several passages given in this analysis.

Discovery IX. *The air expired is no necessary index of that inspired.*

"This calls upon us to revert once more to the important fact, that the air expired is no necessary index of that inspired. Being a mixture of a small part of the air just inspired (the rest having become resident in the chest) with a large quantity of the resident air, its quantity is no measure of the quantity of the air previously inspired; unless the experiment is carried through a large number of respirations, and with the caution, at the end, of ascertaining that the resident air has not been breathed out. Any one who will make the trial will find, at the termination of it, an inclination to relieve a feeling of constraint, which has been produced, by a deep inspiration or sigh. This proves that resident air has been expelled in making the expirations balance in quantity the inspirations."†

It has already been remarked, that to arrive at correct or comprehensive views on the subject of animal heat, it is essential to study the influence of the two acts of respiration; and the consequences flowing from a preponderance of either, as to the changes in the qualities of the blood, as well as to the volume of the air in the chest, are stated in numerous passages. He calls attention to this important fact, that the quantity of air expired, is no measure of the quantity of air previously inspired.

* Principles of Medicine, p. 345. † Opus cit. p. 110.

In the appendix to the "Experimental Inquiry," to prevent the possibility of a misconception of my views on this subject, the subjoined explanation is given.

"In § XI. XII. p. 8 and 9—I have spoken of the influence of inspirations when they preponderate, either in *number* or *perfection* over the expirations. I have observed that, in such cases, they have the tendency to determine the blood to the internal organs. It may appear to some impossible that either expirations or inspirations can have an ascendancy, since it seems necessary that the quantity of air expired, must, upon the whole, be equal to that which is inspired. But, if we carefully consider the phenomena which accompany either of these respiratory acts, we shall be convinced of the correctness of these statements. When an individual speaks vehemently, or runs violently, he very soon exhibits *shortness of breathing*. We perceive that the chest and the shoulders, immediately after the exercise, are raised with great force, arising from the very *deep inspirations* which the individual is necessitated to make, *in order to re-establish in the lungs the ordinary quantity of air, which has been expended in those efforts of the system attendant on running and vehement speaking*. Most individuals can count 30 or 40, commencing with unit, without taking one inspiration. When they arrive at the limit beyond which they cannot pass, they are observed to make a very *deep inspiration*, which draws in at one time the same quantity of air which had been expelled by 30 or 40 previous *expirations*. The proof of this is, that they can re-commence *counting* with facility. In this illustration we perceive that *one* inspiration is equal to 30 or 40 expirations, therefore we can say, that an inspiration is *perfect or complete* according to the effects which it produces. The orator can speak for hours without experiencing the want of breath; but this circumstance is evidently to be attributed to the constant pauses, inseparable from temperate or even energetic speaking. Inspirations may preponderate either in *number* or *perfection*, from different causes. In one instance, the *momentary* depressing states of the mind, in the other similar mental conditions, but of a less acute nature, as for example grief, will occasion them. In the latter, the occasional *sighs* are *inspirations*, which indicate, in many circumstances, *a disordered state of the circulation of the blood in the lungs*. When *inspirations* occur

in consequence of sudden emotions of the mind, they are excited by impressions which the sensorium has received from some external object; but when they take place in depressing passions of a continuous nature, they are occasionally to be referred to congestion of blood in the lungs, conjoined with the operation of the mental cause. And I may here remark, that, although this preponderance of the one act of respiration over the other is only temporary, and their equilibrium is soon restored, yet the irregularity is often of sufficient continuance to admit of changes taking place fully calculated to account for the morbid results attributed to them in this work."*

It would be a waste of time after this lengthy and explicit extract, to attempt to prove that the air expired is stated by me in the most distinct terms, to be no *measure* of the air inspired, and conversely, the air inspired no measure of the air expired, studying the quantity in relation to the successive acts of respiration. It is obvious that, in a given time, the quantity must be precisely the same.

He discovers another advantage arising from the great quantity of air always resident in the chest, illustrative of the practical character of his views. He says:

"Lastly, the collateral, but very important duty of the chest in speaking, especially in oratory, requires the command of both the supplementary and complementary spaces. The duration of an act of expiration is greatly increased in giving expression to a long sentence. The chest has to be nearly filled with air: the air, occupying almost the whole of the complementary space, is first spoken forth, then that of the region of the breath; and in a long sentence, forcibly uttered, a large demand is also made upon the supplementary air. But for this long range, there could be no powerful *eloquence*."†

The very same advantage is stated in the most distinct terms in a passage already quoted; in which it is observed,

* Appendix to Experimental Inquiry, p. 1. The passages in italics, as originally printed. † Opus cit. p. 45.

that "this contrivance," (the structure which allows a large quantity of air to exist in the chest,) "is a wise provision of nature, as it enables an individual to *speak*, laugh, run, in fine, to accommodate himself to any kind of exercise, where expiratory actions are required, without immediately affecting the office of the lungs."*

It would be difficult to find in the writings of any author, coincidences, with the researches of another, not only in important principles, but in the application of them to the explanation of the phenomena of life, so extensive, as have been pointed out in these pages. His treatise in fact, is evidently got up to promote the sale of an article—the Respirator—which he has patented. The spirit which this exhibits, is anything but dignified in one belonging to an honorable profession—a profession which studies to relieve the sufferings of humanity. If his invention possesses one-tenth part of the value which he assigns to it, the use of it should not be limited by exclusive rights. The public at large should have the advantage, on such terms, as the freest competition of the manufacturers can give. The money-making desire should be merged in the wide wish to benefit mankind.

* Experimental Inquiry, &c. p. 14.

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